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EPIDEMIOLOGY & RISK FACTORS

## Genital Pain and Numbness and Female Sexual Dysfunction in Adult Bicyclists



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### ABSTRACT

**Introduction:** Bicycle seat pressure on the perineum may impair arousal and clitoral erection, likely contributing to genital pain and numbness experienced by female cyclists.

**Aim:** We aimed to identify the association between genital pain and numbness experienced by female cyclists and female sexual dysfunction (FSD).

**Methods:** Female cyclists were recruited to complete an online survey using the Female Sexual Function Index (FSFI), a validated questionnaire to assess FSD. Cyclist demographics, experience, preferred riding style, use of ergonomic cycle modifications, and genital discomfort while riding were also queried. Multivariate logistic regression analysis was used to evaluate risk factors of FSD.

**Main Outcome Measures:** The main outcome was FSFI score, which is used to diagnose FSD when the FSFI score is <26.55.

**Results:** Of the survey respondents, 178 (53.1%) completed the survey and FSFI questionnaire. Mean age was 48.1 years ( $\pm 0.8$  standard error [SE]), and the average riding experience was 17.1 years ( $\pm 0.9$  SE). Overall, 53.9% of female cyclists had FSD, 58.1% reported genital numbness, and 69.1% reported genital pain. After adjusting for age, body mass index, relationship status, smoking history, comorbidities, and average time spent cycling per week, females who reported experiencing genital numbness half the time or more were more likely to have FSD (adjusted odds ratio [aOR], 6.0; 95% CI, 1.5–23.6;  $P = .01$ ), especially if localized to the clitoris (aOR, 2.5; 95% CI, 1.2–5.5;  $P = .02$ ). Females that reported genital pain half the time or more while cycling also were more likely to have FSD (aOR, 3.6; 95% CI, 1.2–11.1;  $P = .02$ ). Cyclists experiencing genital pain within the first hour of their ride were more likely to have FSD (aOR, 12.6; 95% CI, 2.5–63.1;  $P = .002$ ). Frequency and duration of cycling were not associated with FSD. Analysis of FSFI domains found that the frequency of numbness was correlated with decreased arousal, orgasm, and satisfaction during intercourse, whereas the frequency of pain significantly reduced arousal, orgasm, and genital lubrication.

**Clinical Implications:** Female cyclists that experience numbness and/or pain have higher odds of reporting FSD.

**Strengths & Limitations:** Our study includes a validated questionnaire to assess FSD and queries specific characteristics and symptoms of genital pain and genital numbness; however, the study is limited by its cross-sectional survey design.

**Conclusion:** This study highlights the need for cyclists to address genital pain and numbness experienced while cycling, and future studies are required to determine if alleviating these symptoms can reduce the impact of cycling on female sexual function. **Greenberg GR, Khandwala YS, Breyer BN, et al. Genital Pain and Numbness and Female Sexual Dysfunction in Adult Bicyclists. J Sex Med 2019; 16:1381–1389.**

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**Key Words:** Female Sexual Dysfunction; Bicycling; Sexual Health

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## INTRODUCTION

Bicycle riding is a low-impact endurance sport with numerous long-term health benefits; however, continuous perineal pressure during prolonged periods of time spent in a saddle can decrease genital sensation.<sup>1</sup> Altered genital sensation from cycling and its effect on sexual function remain controversial.<sup>2–4</sup> One hypothesized mechanism is that the saddle compresses and/or entraps the pudendal nerve, resulting in injury. This mechanism has been identified as a potential cause of sexual dysfunction in females.<sup>5,6</sup>

Female sexual dysfunction (FSD) is a highly prevalent condition that can cause anxiety regarding relationships and sexuality.<sup>7,8</sup> It has also been linked to a decrease in overall quality of life.<sup>9</sup> Although the effects of FSD have been well studied, the etiology is less understood. FSD is complex and often multifactorial, as it includes physiological, psychological, and social factors. In men, the association between cycling and sexual dysfunction has been previously explored.<sup>3,10–12</sup> However, studies of cycling and sexual function in males cannot be appropriately applied to female cyclists due to gender differences in pelvic anatomy, weight support, pelvic motion while riding, and physiologic responses to ergonomic cycle modifications.<sup>13–15</sup>

Previous studies on the effect of cycling on female sexual function are limited to case series or observational studies, and only 1 study has utilized a validated questionnaire.<sup>16,17</sup> We thus queried respondents on several characteristics of their experienced genital numbness and genital pain, in addition to utilizing the Female Sexual Function Index (FSFI), a validated questionnaire, to assess FSD. We sought to determine the effect of demographic information, cycling characteristics, and experience with genital numbness and/or genital pain while cycling on sexual function in a cohort of female cyclists. Our primary objective was to identify factors associated with increased odds of reporting FSD, genital numbness, and/or genital pain. Our second objective was to identify if certain characteristics of experienced genital pain and/or genital numbness were associated with increased odds of reporting FSD. Finally, we sought to identify which domains (desire, arousal, lubrication, orgasm, satisfaction, and pain) of sexual dysfunction were most affected in female cyclists.

## METHODS

### Study Participants and Recruitment

Female cyclists 18 years of age or older were recruited to complete an anonymous survey. We recruited through outreach online and via print (eg, websites, cycling magazines), as well as by cycling podcasts, cycling group list serves, and social media (eg, Facebook). This study was approved by the institutional review board at Stanford University School of Medicine. In accordance with the approved protocol, survey respondents signed electronic informed consent prior to beginning the study.

### Study Variables

We collected data on demographics that included age, race/ethnicity, body mass index (BMI), smoking status, and comorbidities, such as history of hypertension, diabetes, cardiovascular disease, or arthritis. Cyclists were queried regarding their self-defined riding classification (commuter, recreational, enthusiast, or professional), riding style (road biking, mountain biking, or triathlons), riding experience, average distance cycled per week, average time spent cycling per week, and number of rides 3 hours or longer per month. Information regarding the use of protective clothing and ergonomic cycle modifications was also collected, including saddle type, saddle padding, use of cycling shorts, and whether the rider was professionally fitted for their bicycle type and size.

### Outcome Measures

Female sexual dysfunction was assessed using the FSFI. This questionnaire is a validated tool to assess overall sexual health and has been proven to have high reliability, validity, sensitivity, and specificity in identifying FSD.<sup>18</sup> It includes 19 questions that query 6 sexual health domains that are scored independently, including desire (range 1.2–6.0), arousal (range 0.0–6.0), lubrication (range 0.0–6.0), orgasm (range 0.0–6.0), satisfaction (range 0.8–6.0), and pain (range 0.0–6.0). FSFI total score is an aggregate of each domain. Scores range from 2 to 36, and a score of less than 26.55 results in the diagnosis of FSD.<sup>18,19</sup> We controlled for sexual activity (yes/no) based on responses from questions 3 to 14 on the FSFI, as total score can be falsely low in women who are not sexually active.<sup>20</sup> Non-validated questions were used to assess study participants' experience of pain and genital numbness while cycling. Survey respondents were asked if they experienced genital numbness and/or genital pain while cycling. Response options included “never,” “sometimes,” or “half the time or more.” Individuals reporting genital numbness/pain “sometimes” or “half the time or more” were considered to be experiencing genital numbness and/or pain when analyzed as a binary outcome. Information regarding the frequency, location, severity, onset, and time to resolution of each type of genital pain and genital numbness was collected.

Our primary analysis utilized demographic information, cycle specifications and modifications, and characteristics of cycling (eg, average hours of cycling per week) as independent variables to assess their association with FSD, as well as the binary outcomes (yes/no) of genital pain and genital numbness experienced while cycling. Our secondary analysis sought to identify the association between specific characteristics of experienced genital pain and genital numbness and FSD. Therefore, the frequency, severity, time of onset, and time of resolution of experienced genital numbness and genital pain were considered independent variables to assess their association with FSD.

## Statistical Analyses

Data were analyzed using Stata 15.1 (StataCorp; College Station, TX) statistical software. Graphical analyses were performed using Prism 8.02 (GraphPad; La Jolla, CA). Linear regression was used to determine associations between cycling characteristics and continuous outcomes. Univariate and multivariate logistic regression was used for categorical outcomes. Confounding variables were chosen a priori for our analysis based on their relationship with cycling intensity and duration. These variables included age, BMI, relationship status, smoking history, comorbidities, and average time spent cycling per week. The variables were assessed for collinearity before being included in our multivariate model. Univariate and multivariate analyses were used to determine predictive factors associated with pain, numbness, and FSD. Analysis of variance was used to analyze the effect of pain and numbness characteristics on mean score of each FSFI domain, and post hoc Mann-Whitney *U* tests were performed to identify statistically significant results. All tests were 2 sided, and a *P* value of  $<.05$  was deemed statistically significant. Measures of central tendency were reported as mean  $\pm$  standard error (SE).

## RESULTS

In total, 335 female cyclists participated in the study, and 178 (58.1%) completed the online survey and FSFI questionnaire. The average age of all participants was  $48.1 \pm 0.8$  years, of whom two-thirds were over 40 years of age. The majority of survey participants were white (88.9%), and most used a road bike when cycling (98.1%). Average riding experience was  $17.1 \pm 0.9$  years, and over 30% of riders had over 20 years of experience. Demographic information for all survey participants is shown in Table 1.

### Demographics and Cycling Characteristics and Effect on FSD

The mean FSFI total score among all survey participants was  $22.0 \pm 0.81$ , and over half (53.9%) met the diagnostic criteria for FSD (FSFI total score  $< 26.55$ ). Univariate analyses showed no correlation among demographic information, cycling characteristics, cycle modifications, or protective equipment and female sexual dysfunction (Tables 2 and 3).

### Demographics and Cycling Characteristics and Effect on Genital Numbness and Genital Pain

Numbness was reported in 58.2% of female cyclists, and pain was reported in 69.1% of surveyed individuals. The locations in which numbness and pain were experienced followed a similar pattern, most commonly reported in the labia, followed by the clitoris, buttocks, and perineum; 51.4% of respondents rated their pain as “moderate to severe” compared to 47.0% of those who experienced numbness. Overall, the percentage of individuals who experienced pain and numbness differed in their frequency ( $P = .04$ ) and duration of time to resolution

**Table 1.** Demographics and riding characteristics of survey participants

Demographics	Value
Age (y), mean (SEM)	48.1 (0.78)
Body mass index, mean (SEM)	23.9 (0.26)
Race/ethnicity, n (%)	
African American or black	2 (0.6)
American Indian or Alaska Native	2 (0.6)
Asian	21 (6.3)
Hispanic or Latino	10 (3.0)
White or Caucasian	297 (88.9)
Other	2 (0.6)
Country, n (%)	
United States	242 (72.2)
Non-United States	93 (27.8)
Rider classification, n (%)	
Commuter	49 (15.6)
Recreational	66 (21.1)
Enthusiast	189 (60.4)
Professional	9 (2.9)
Rider style, n (%)	
Road	307 (98.1)
Mountain	92 (29.4)
Triathlon	28 (8.9)
Total biking, n (%)	
0–10 y	154 (49.5)
>10–20 y	62 (19.9)
>20 y	95 (30.6)
Biking distance, n (%)	
0–80 km/wk	98 (34.6)
>80–160 km/wk	74 (26.2)
>160 km/wk	111 (38.2)
Rides $\geq 3$ hr per month, n (%)	
0–1	134 (43.7)
>1–4	95 (30.9)
>4	78 (25.4)

SEM = standard error of the mean.

( $P < .001$ ) (Figure 1). Individuals over 60 years of age, which comprised of 22.7% of our survey population, were less likely to report numbness during their ride (odds ratio [OR], 0.3; 95% CI, 0.1–0.9;  $P = .02$ ). Cyclists that rode an average of  $>10$  hours per week were more likely to report pain (OR, 2.4; 95% CI, 1.1–5.2;  $P = .03$ ), but riders using a wide-cut saddle were less likely to report pain (OR, 0.3; 95% CI, 0.1–0.8;  $P = .02$ ).

### Characteristics of Genital Numbness and Genital Pain and Effect on FSD

Multivariate analysis showed that frequency and location of numbness had the greatest impact on the odds of experiencing FSD. Cyclists who experienced genital numbness and genital pain half the time or more while cycling were more likely to report FSD (aOR, 6.0; 95% CI, 1.5–23.6;  $P = .01$  and aOR, 3.6; 95% CI, 1.2–11.1;  $P = .02$ , respectively), and females that

**Table 2.** Female sexual dysfunction, genital pain, and genital numbness associated with demographic information and riding characteristics

Demographics	FSD OR (95% CI)	<i>P</i> value (<.05)	Numbness OR (95% CI)	<i>P</i> value (<.05)	Pain OR (95% CI)	<i>P</i> value (<.05)
Age (y)						
≤30	Ref		Ref		Ref	
>30–40	0.4 (0.1–1.3)	.15	0.9 (0.3–2.6)	.86	1.1 (0.4–3.7)	.82
>40–50	0.4 (0.1–1.4)	.15	0.5 (0.2–1.6)	.26	0.8 (0.2–2.6)	.69
>50–60	0.7 (0.2–2.1)	.53	0.6 (0.2–1.7)	.35	0.9 (0.3–2.8)	.89
>60	1.6 (0.5–5.5)	.45	0.3 (0.1–0.9)	.02	0.9 (0.3–2.9)	.92
Body mass index						
≤24.9 (normal)	Ref		Ref		Ref	
25–29.9 (overweight)	0.7 (0.3–1.4)	.29	1.0 (0.5–1.9)	.99	0.7 (0.3–1.3)	.25
≥30 (obese)	2.7 (0.8–8.7)	.10	1.5 (0.6–4.0)	.38	1.4 (0.5–4.7)	.53
Rider type						
Commuter	Ref		Ref		Ref	
Recreational	0.6 (0.2–1.8)	.39	1.2 (0.5–3.0)	.69	1.5 (0.6–4.0)	.40
Enthusiast	0.8 (0.3–1.9)	.58	1.3 (0.6–2.8)	.47	1.7 (0.8–3.7)	.18
Professional	1.0 (0.1–7.1)	1.0	1.2 (0.2–6.1)	.84	3.5 (0.4–33.3)	.28
Total time cycling (y)						
0–10	Ref		Ref		Ref	
>10–20	1.0 (0.5–2.1)	.97	1.1 (0.6–2.2)	.81	0.9 (0.4–1.9)	.70
>20	1.3 (0.6–2.7)	.49	0.6 (0.3–1.2)	.14	0.6 (0.3–1.1)	.09
Average riding time (hr/wk)						
0–5	Ref		Ref		Ref	
>5–10	1.2 (0.6–2.5)	.59	1.1 (0.6–2.0)	.81	1.8 (0.9–3.6)	.08
>10	0.9 (0.4–1.8)	.71	1.5 (0.8–3.1)	.21	2.4 (1.1–5.2)	.03
Average riding distance (km/wk)						
0–80	Ref		Ref		Ref	
>80–160	1.3 (0.6–3.1)	.53	0.7 (0.3–1.4)	.29	0.9 (0.4–2.1)	.88
>160	0.9 (0.5–1.9)	.80	1.0 (0.5–2.0)	.95	1.8 (0.8–3.8)	.13
Long rides (≥3 hr)						
0–1 rides/mo	Ref		Ref		Ref	
>1–4 rides/mo	1.9 (0.9–3.8)	.08	0.8 (0.4–1.4)	.39	1.1 (0.5–2.1)	.86
>4 rides/mo	1.6 (0.8–3.3)	.22	0.9 (0.4–1.7)	.65	1.6 (0.7–3.4)	.25

FSD = female sexual dysfunction; OR = odds ratio.

experienced numbness in the clitoris were more likely to report FSD, as well (aOR, 2.5; 95% CI, 1.2–5.5;  $P = .02$ ). In contrast to numbness, the time to onset of pain was a stronger predictor of FSD. Cyclists who experienced pain 1 to 5 hours into their ride were more likely to report FSD (aOR, 4.4; 95% CI, 1.3–15.1;  $P = .02$ ), and those who experienced pain <1 hour into their ride were even more likely to report FSD (aOR, 12.6; 95% CI, 2.5–63.1;  $P = .002$ ) (Table 4).

### Characteristics of Genital Numbness and Genital Pain and Effect on FSFI Domains

Frequency of numbness was strongly associated with the FSFI-orgasm domain score. Cyclists that experienced numbness half the time or more had significantly lower FSFI-orgasm domain scores compared to cyclists that never experience numbness

( $5.1 \pm 0.15$  vs  $3.7 \pm 0.45$ ;  $P < .01$ ). This same trend was present for both arousal ( $P < .01$ ) and satisfaction ( $P = .01$ ) (Figure 2A). Increased frequency of pain was associated with decreased FSFI-arousal and FSFI-orgasm domain scores, as well. It was also associated with decreased FSFI-lubrication domain scores when comparing cyclists who never experience pain compared to cyclists with genital pain half the time or more ( $5.2 \pm 0.20$  vs  $4.3 \pm 0.28$ ;  $P < .01$ ) (Figure 2B). Earlier onset of pain was associated with decreased FSFI-lubrication, FSFI-satisfaction, and FSFI-pain domain scores (Figure 2C). A complete analysis of characteristics of numbness and pain on FSFI-domain scores is provided in Supplementary Table 1. Average distance cycled per week, average time riding per week, years of riding experience, and number of long rides (≥3 hours) per month did not have a significant correlation with any of the FSFI domains (Supplementary Table 2).

**Table 3.** Cycle specifications and safety features and their effect on female sexual dysfunction, genital numbness, and genital pain

Features	FSD OR (95% CI)	P value (<.05)	Numbness OR (95% CI)	P value (<.05)	Pain OR (95% CI)	P value (<.05)
Saddle riding position						
Back	Ref		Ref		Ref	
Center	1.2 (0.6–2.5)	.55	1.1 (0.6–2.1)	.76	0.8 (0.4–1.7)	.58
Front	1.2 (0.5–2.9)	.63	0.9 (0.4–1.9)	.68	1.5 (0.6–4.0)	.37
Certified bike fitting						
Prior fitting	1.8 (1.0–3.4)	.07	1.1 (0.7–2.0)	.67	1.7 (0.9–3.1)	.09
Cycle/saddle specifications						
Aero bars	1.5 (0.5–4.2)	.49	1.7 (0.7–4.4)	.25	1.1 (0.4–3.0)	.86
Adjustable saddle width	1.0 (0.6–1.9)	.91	1.1 (0.6–1.9)	.76	0.8 (0.4–1.4)	.38
Saddle length (>250 mm)	1.1 (0.6–2.2)	.72	0.8 (0.4–1.5)	.46	0.9 (0.4–1.7)	.72
Sit bones measured	0.9 (0.3–2.9)	.84	1.5 (0.5–4.5)	.45	1.1 (0.3–3.8)	.87
Manufactured health benefit	0.7 (0.3–1.4)	.28	1.5 (0.8–2.8)	.25	1.9 (0.9–4.3)	.12
Saddle padding						
None	Ref		Ref		Ref	
Minimal	0.9 (0.3–2.3)	.77	0.8 (0.3–2.1)	.68	1.3 (0.5–3.8)	.57
Moderate	1.0 (0.4–2.7)	.98	0.8 (0.3–1.9)	.56	1.1 (0.4–3.1)	.84
Heavy	1.6 (0.2–11.1)	.61	1.8 (0.3–10.9)	.52	1.6 (0.3–10.2)	.61
Saddle cut						
Cut-out	Ref		Ref		Ref	
Groove	0.7 (0.3–1.4)	.28	1.3 (0.7–2.4)	.46	0.8 (0.4–1.6)	.50
Nose-less	0.5 (0.1–3.2)	.48	4.1 (0.5–36.1)	.20	1.0 (0.1–10.3)	.98
Wide	1.2 (0.4–3.4)	.71	1.8 (0.7–4.6)	.25	0.3 (0.1–0.8)	.02
Personal safety						
Cycle shorts	1.5 (0.6–4.1)	.40	0.7 (0.3–1.7)	.43	1.1 (0.8–2.8)	.79
Lubrication (eg, chamois)	1.6 (0.9–3.0)	.10	1.3 (0.8–2.2)	.32	1.6 (0.9–2.8)	.15

FSD = female sexual dysfunction; OR = odds ratio.

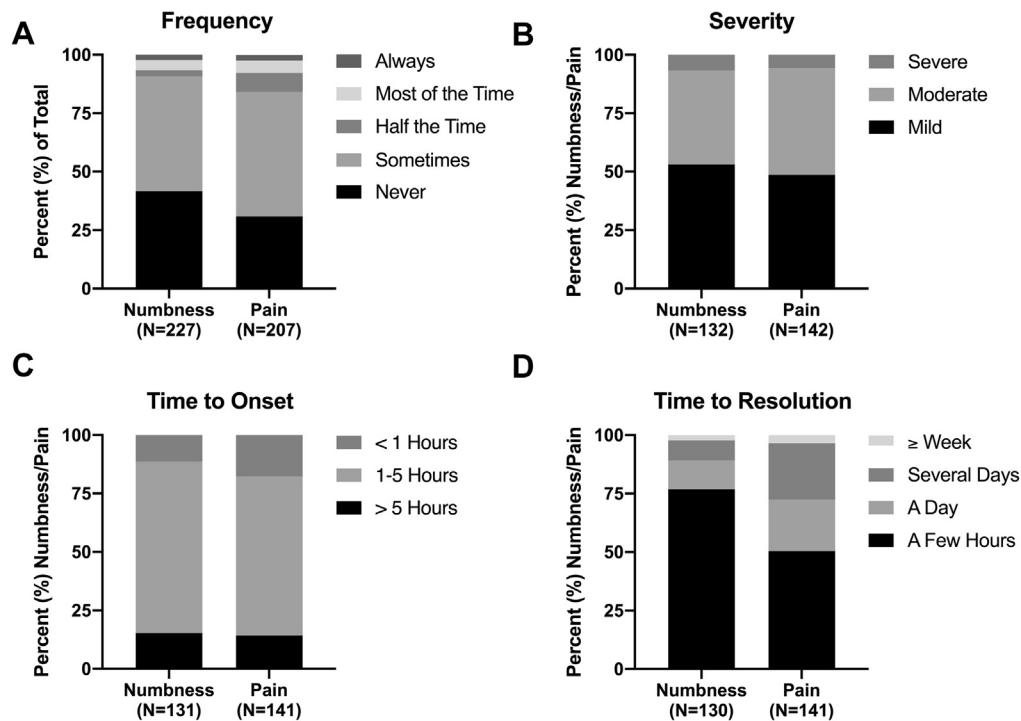
## DISCUSSION

This study explored the associations among bicycle riding, genital pain and genital numbness, and female sexual dysfunction. We found that female cyclists who experienced frequent genital numbness and early onset of genital pain while cycling were more likely to report sexual dysfunction. We also found that genital pain and numbness from cycling were strongly associated with both decreased arousal and satisfaction with orgasm in females. Because cycling has become an increasingly popular mode of exercise and transportation, especially among women, this study provides valuable information to better understand the scope of genital risks in this population. Between 2003 and 2012, the number of women participating in cycling rose 20%, and over 60% of bicycle owners ages 17 to 28 years old are female.<sup>21,22</sup> The health benefits from cycling include improved cardiovascular health and weight control and decreased risk of breast cancer in women.<sup>23–25</sup> Although the net positive benefits of cycling are well established, prolonged time spent in a bicycle saddle has been hypothesized to have deleterious effects on sexual function. Correlations between cycling and erectile dysfunction in men have been explored; however, there is less information available to identify potential risks in female cyclists, highlighting the importance of our findings.<sup>26</sup>

Our overall prevalence of sexual dysfunction was high among our study population (53.9%) using a cutoff of FSFI of <26.55; however, our rate of FSD is comparable to previous studies in cyclists, as well as epidemiological studies surveying the general population.<sup>17,27</sup> We found no strong correlation among patient demographics (including age and BMI), cycling characteristics, or cycle/saddle features with regard to the odds of reporting FSD.

Previous reports on sexual function in female cyclists have been heterogeneous. Some suggest that cycling is strongly correlated with sexual dysfunction, with higher rates of dyspareunia, anorgasmia, and changes in sexual sensation. For example, Hermans et al<sup>28</sup> analyzed female sexual function in 114 cyclists and found that 18.4% reported a change in sexual sensation and 12.8% reported difficulties reaching orgasm. In contrast, when Gaither et al<sup>17</sup> surveyed a larger cohort of cyclists and non-cyclists, they found that high-intensity cyclists, characterized by riding experience of at least 2 years, riding more than 3 times per week, and riding a daily average of >25 miles, had lower odds of reporting sexual dysfunction compared to non-cyclists. These findings make it difficult to reach a consensus decision regarding the association between cycling and female sexual dysfunction. Further confounding factors including menopausal status, hormonal therapy, and pathologic causes of pelvic discomfort, such as endometriosis, may influence the





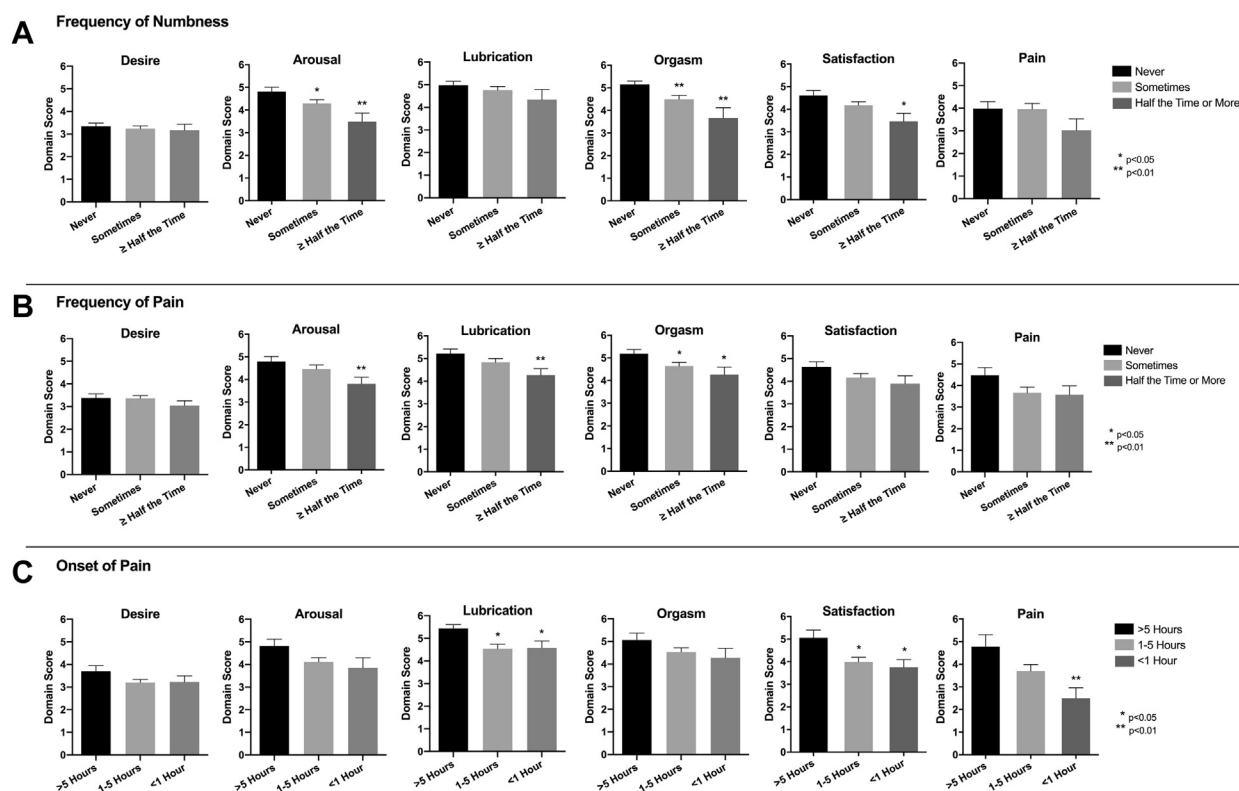
**Figure 1.** Comparison of reported characteristics of genital numbness and pain among female cyclists, stratified by percentage of respondents. Categorical variables were analyzed using  $\chi^2$  tests. (A) Frequency of numbness and pain ( $P = .04$ ). (B) Severity of numbness or pain among respondents reporting these symptoms ( $P = .63$ ). (C) Time to onset of numbness or pain among respondents reporting these symptoms ( $P = .34$ ). (D) Time to resolution of numbness or pain among respondents reporting these symptoms ( $P < .001$ ).

**Table 4.** Characteristics of genital numbness and genital pain associated with female sexual dysfunction

Characteristics	Numbness		Pain	
	FSD OR* (95% CI)	P value (<.05)	FSD OR* (95% CI)	P value (<.05)
<b>Frequency</b>				
Never	Ref		Ref	
Sometimes	1.5 (0.8–3.0)	.23	1.4 (0.6–2.9)	.43
≥Half the time	6.0 (1.5–23.6)	.01	3.6 (1.2–11.1)	.02
<b>Location</b>				
Labia	1.7 (0.9–3.4)	.11	1.1 (0.6–2.1)	.75
Clitoris	2.5 (1.2–5.5)	.02	1.8 (0.8–3.8)	.13
Buttocks	0.8 (0.3–1.9)	.60	1.0 (0.4–2.3)	.93
Perineum	2.4 (0.9–6.4)	.08	1.4 (0.5–3.6)	.54
<b>Severity</b>				
Mild	Ref		Ref	
Moderate to severe	1.5 (0.7–3.6)	.34	1.2 (0.5–2.6)	.69
<b>Onset (hr)</b>				
>5	Ref		Ref	
1–5	2.6 (0.8–8.1)	.10	4.4 (1.3–15.1)	.02
<1	3.6 (0.6–21.3)	.15	12.6 (2.5–63.1)	.002
<b>Time to relief</b>				
A few hours	Ref		Ref	
A day	1.6 (0.5–5.3)	.43	0.3 (0.1–0.8)	.02
≥Several days	1.4 (0.3–6.8)	.68	1.3 (0.5–3.5)	.65

FSD = female sexual dysfunction; OR = odds ratio.

\*Odds ratios are adjusted for age, body mass index, relationship status, smoking history, comorbidities, and average hours of cycling per week.



**Figure 2.** Effect of characteristics of numbness and pain on individual domains of the FSFI. P-Values compare each characteristic to the baseline of either 'Never' numbness or pain (A and B) or onset of pain '>5 Hours' (C). Measure of central tendency are shown as mean  $\pm$  standard error. Analyses use mann-Whitney U test to determine statistical significance.

association between genital pain and genital numbness and FSD.<sup>29,30</sup> It is possible that differences in study populations and the use of both validated and non-validated questionnaires have also made it difficult to directly compare and aggregate results.

The proportion of female cyclists who experience genital numbness from riding has been reported to be between 34% and 40%.<sup>17,31</sup> Our rate (58.2%) is higher than those reported in previous publications, but it is similar to rates found among male cyclists.<sup>32–34</sup> The association between cycling and genital numbness has been well established, but its effect on female sexual function is less clear. Previous reports have found that genital numbness from cycling is correlated with increased rates of dyspareunia and dysuria and decreased genital sensation.<sup>1,28</sup> In our study, we found that increased frequency of numbness and numbness localized to the clitoris increased the odds of reporting FSD. Moreover, we found that the frequency of numbness was most strongly associated with decreased arousal, orgasm, and satisfaction with intercourse. Although we did not collect physiological data, this frequency-dependent relationship suggests that repeated interruptions of blood flow and/or nerve entrapment can decrease genital sensation and increase odds of FSD. This similar mechanism has linked genital numbness caused by hypooxygenation of the corpus cavernosum in male cyclists with a higher incidence of erectile dysfunction.<sup>35</sup> However, the results of these studies in men remain controversial, as they often fail to compare findings with an appropriate control group.

With regard to genital pain, individuals who experienced genital pain half the time or more while cycling and those with a shorter duration to onset of pain were most predictive of reporting FSD, in addition to being strongly associated with decreased arousal, orgasm, and genital lubrication. Shorter time to onset of genital pain was associated with dyspareunia defined by the FSFI pain domain. Genital pain from cycling has been linked to micro-hematomas, inflammation, and degenerative processes in the groin which may account for their effect on overall sexual function.<sup>36</sup>

Researchers and bicycle manufacturers have increasingly focused on creating ergonomic saddles and cycle modifications to reduce genital pain and numbness. Previous studies have also shown that using a correct bicycle size with a professional fitting, as well as standing in the saddle, have had modest effects on decreasing genital discomfort.<sup>17</sup> Increased saddle width has been shown to decrease stress on the perineum, decreasing average and peak perineal saddle pressure experienced by female cyclists.<sup>37,38</sup> A prospective study comparing a conventional saddle to a wider bicycle saddle showed that the wider saddle lowered rates of saddle-related symptoms and was subjectively more comfortable on rides longer than 2 hours.<sup>39</sup> Consistent with these physiologic studies and previous findings, saddle width was the only cycle specification that decreased the odds of reporting genital pain. Females have a wider ischial tuberosity difference compared to males which may account for this finding. Despite our results, previous studies have found increased saddle width to be



correlated with dysuria and stranguria in female cyclists. Further research is required to elucidate how saddle width can have opposing effects on genital pain and urinary function. Nevertheless, this finding highlights the need for gender to be considered when determining the ideal saddle type for each cyclist.<sup>13</sup> Finally, as bicycle manufacturers have attempted to increase the safety of bicycle saddles, our contemporary series may reflect overall global improvements in saddle design.

## Limitations

Our study is not without limitations. We utilized a cross-sectional survey that potentially introduces recall bias in our results. Similarly, individuals experiencing adverse sexual outcomes as a result of cycling are more likely to decrease their cycling habits, change cycle equipment and saddle type, or choose another form of exercise entirely. Although we aimed to gather data from a diverse study population by using multiple recruitment strategies, we may introduce selection bias caused by the individuals that chose to participate. We also did not query female cyclists on their relationship satisfaction, menopausal status, or partner's sexual dysfunction. In addition, given the number of cycling variables assessed, associations may be due to chance alone. Strengths of our study include a large sample size, use of a validated questionnaire to assess FSD, and the inclusion of questions regarding the frequency, location, severity, onset, and duration of genital pain and numbness.

## CONCLUSION

Female cyclists that experience genital pain or numbness from riding have increased odds of reporting sexual dysfunction; however, different characteristics of genital numbness and genital pain affect varying domains of the FSFI. Our findings suggest that increased research is required to determine the optimal seat design and cycle modifications to reduce these symptoms. Future studies will aim to determine if alleviating genital pain and numbness can improve female sexual function in this population.

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## SUPPLEMENTARY DATA

Supplementary data related to this article can be found online at <https://doi.org/10.1016/j.jsxm.2019.06.017>.